will still, it is to be hoped, cover with noble forests the highest and most inaccessible slopes of the Rocky Mountains, recalling to men, as long as the study of trees occupies their thoughts, the memory of a pure, upright, and laborious life.

THE MAXIMA AND MINIMA TIDE-PREDICTING MACHINE.[1]

THIS machine has been invented by Mr. Ferrel, and constructed by Fauth & Co. of Washington, for the use of the Coast and geodetic survey. Its object is to determine mechanically the times and heights of high and low waters for the numerous tide-stations around our coast, for which tide-tables are annually published. The numerical data for these have been heretofore obtained by computation; but, on account of the great complexity of the tidal theory and formulae, this involves a great amount of labor to obtain even approximate results, and more accurate ones have to be dispensed with, unless they can be obtained in some way mechanically, with much greater facility than by computation.

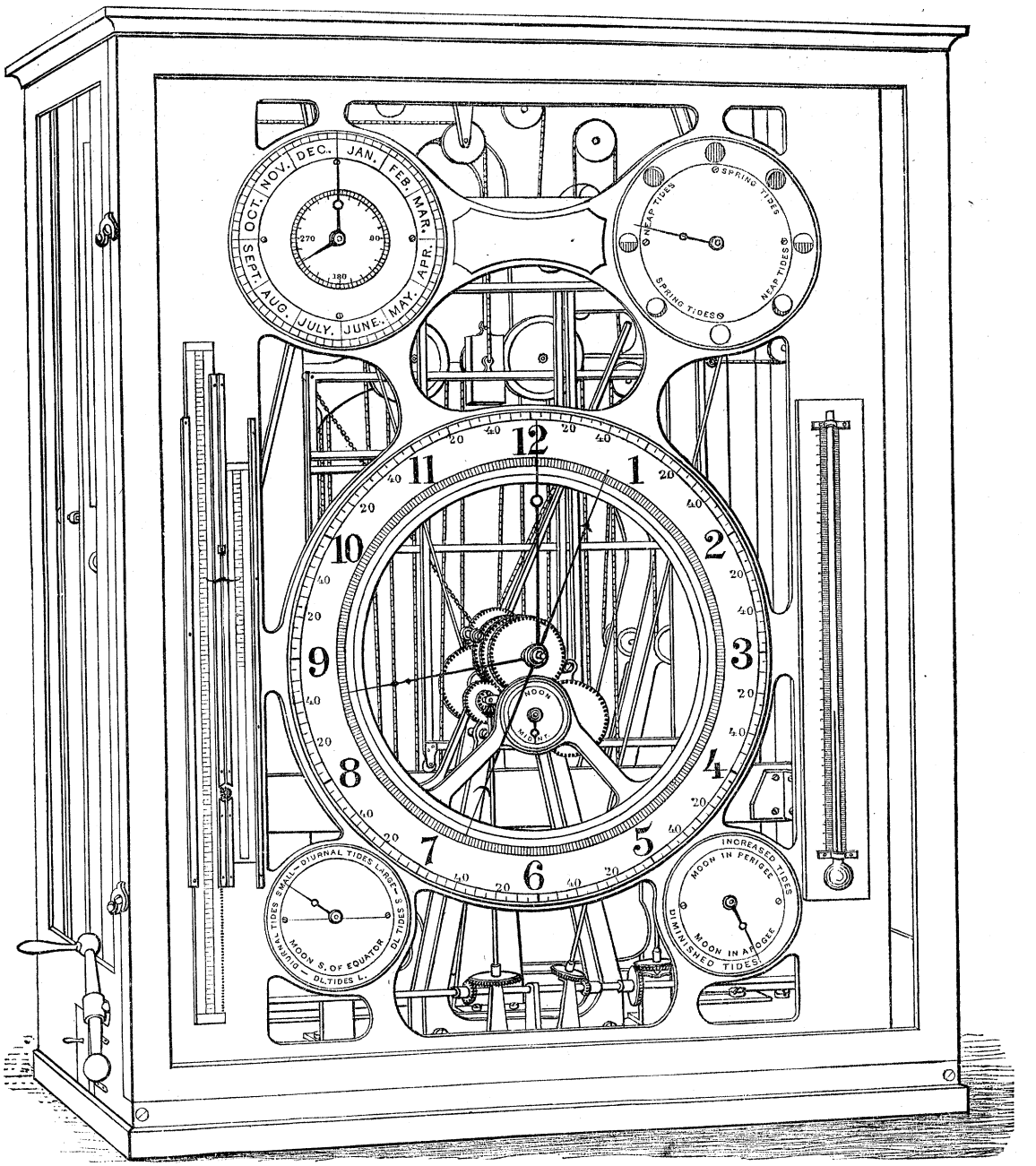
The first tide-predictor was invented by Sir William Thomson, about eight years ago. This was constructed so as to take into account about ten only of the principal tide-components; all, however, which are of much practical importance. This machine has not been used in the regular prediction of tides, and is said to be now on exhibition at the South Kensington museum.

Subsequently Mr. Roberts, of the *Nautical almanac*, London, had another constructed upon somewhat the same plan, but larger, taking into account twice as many of the components, and having some improvements on the plan introduced. A description of this machine was given in *The engineer* of Oct. 19, 1879. It is now being successfully used in the prediction of the tides of India.

Both of these machines have been constructed so as to be run by clock-work, and to give the results in the form of a tide-curve for one year on a roll of paper, from which the times and heights of high and low waters are afterwards read off and recorded.

In the maxima and minima predictor, only the maxima and minima of the heights of the tide above mean low water or any other assumed plane of reference, and the times of their occurrence, are indicated; as these alone are required for the tide-tables annually published. For this purpose a transformation of the tidal harmonic function was necessary, so that it would give heights and times of the maxima and minima; and, as any such transformation usually renders the resulting expression much more complex than the original one, the whole theory and construction of this machine is much more complex than in the case in which the machine is required to give the height of the tide at regular stated intervals of time, or a graphic representation of the whole function. In this machine both the clock-work and roll of paper are dispensed with, and the machine is run by means of a small crank at the side, with the left hand; and the times and heights of high and low waters are read off from the face of the instrument, and recorded as you go, with the right hand, upon blank forms ready for the printer. The great advantage which is claimed for this form of the machine is that it gives only what is required, and this in such a way that the results can be recorded at once, and the trouble of handling long rolls of paper, and estimating the times of maxima and minima, and reading off the corresponding height of the tide, is saved. Although the machine is more complex, this makes no difference in the facility with which the results are obtained. The crank is turned until an index on the central dial of the face, called the lunar index, pointing between eight and nine on the accompanying perspective representation of the face of the instrument, comes in conjunction with the upper end of an oscillating needle, the upper end pointing between twelve and one, as represented, when the time of high water is pointed out by another index on the same dial, called the solar index, pointing, as represented, to the figure twelve, at noon and midnight, and the height is indicated by an index on a vertical scale on the left side of the face of the instrument. You then turn until the lunar index comes in conjunction with the lower end of the needle, when the solar index points out the time of low water, and the index at the side, its height. Turning until the lunar index comes in conjunction again with the upper end of the needle, you read off, as before, the times and heights of the next high water; and so on from high to low and from low to high water through the year, recording the results as you go. Where, however, there are large diurnal components, it is necessary to run through twice, — first for the times, and then, after a little change in the setting, for the heights. The machine, therefore, is especially convenient for most of the tides having a large range upon our At-

[1] This article, written by Mr. WILLIAM FERREL, is published by permission of the superintendent of the Coast and geodetic survey.



lantic coast, since the diurnal components in these are very small.

It would be impossible, in this short sketch, to give any idea of the theory and construction of the machine. These, however, will be contained in an appendix to the report of the superintendent of the U. S. coast and geodetic survey for 1883.

The efficiency of the machine is in general very satisfactory. The results given by it have been compared both with computation and observation. In a comparison with one

month's computation of the tides of Boston harbor, the differences in the heights rarely exceeded more than 0.1 of a foot, and in the times more than three or four minutes. These differences arose from a slight yielding of some parts of the machine from a lack of sufficient rigidity. This, however, could be mostly remedied at small expense, if thought necessary, by making some parts of it a little more rigid.

In a comparison of the results given by the machine for three months, of the tides of San Diego, Cal., having very large diurnal components, with the times and heights from observation, the average of the differences, taken without regard to signs, was 0.29 of a foot, and in the times about ten minutes. But these differences are due mostly to meteorological causes, changes in the winds and in the barometric pressure, which cause fluctuations in the mean level of the sea, and are due only in a small measure to imperfections of the machine. These are most conspicuous in cases where the tide-wave becomes very flat from the high or low water of any day being brought very nearly to mean sea-level from the effect of large diurnal components, or where the whole range of the tide is very small; but in such cases the times of maxima and minima are very indefinite, and the error is more in appearance than in reality.

The machine is now being used in the prediction of the tides for the tide-tables of the year 1885, and is in all cases first applied for each station to some year for which there are observations for comparison, and, with the exception of the slight defect referred to, is giving entire satisfaction. The capacity of the machine for doing work is at least that of thirty to forty computers, if these were to take into account every thing which the machine does. In fact, little more time is required than that which is taken up in recording the results.

NOTES ON THE LAVA-FLOW OF 1880-81 FROM MAUNA LOA.

The Hawaiian Islands are entirely of volcanic origin. The various islands appear very distinctly to be of different ages, the volcanic agencies still being continually active in the most south-easterly one, while in those to the north-west they have been extinct for a long period of time.

Hawaii, the largest island, situated at the extreme south-west of the group, has an area of about 4,200 square miles, being about twice the size of the state of Delaware, and not quite so large as Connecticut. It has four prominent elevations, each of which marks what is or has been a centre of activity. The Kohala Mountains, with an elevation of about five thousand feet, form the northern end of the island: though thickly covered with well preserved crater-cones, their activity ceased before the earliest traditions of the natives. Mauna Kea, the highest peak of the group, with an altitude of 13,825 feet, has also long been extinct. This lies to the south-east of the Kohala Mountains, on the eastern coast. Nearly opposite, on the western coast, is Mauna Hualalai, a little more than 8,000 feet in height. The last recorded eruption from this took place in the year 1801. When visited in the spring of 1882 by J. T. Perryman and J. S. Emerson of the Hawaiian government survey, steam was found to be issuing from several of the fissures on the summit.

South of the preceding three elevations is Mauna Loa, on whose summit, 13,610 feet above the sea, is the active crater of Mokuweoweo. The slopes of Mauna Loa are very gentle, and, when seen from a distance, the whole mountain appears like a gentle swell of land. On its eastern slope, at an elevation of about 4,000 feet, is the famous active crater of Kilauea. This is commonly regarded as a portion of the mountain of Mauna Loa; but it is in reality a separate mountain, though situated so near the other that the lavas from each have flowed together till the outline of this mountain has nearly been merged in that of the other. As seen from the upper portions of Mauna Loa, the individuality of Kilauea is clearly apparent.

During the last hundred years many flows of lava have taken place from both these mountains; all bursting forth from the sides approximately near the summit, but none coming from the crater itself. These have been well described by Rev. Mr. Coan of Hilo, Hawaii, by W. T. Brigham of Boston, and others.

On the 6th of November, 1880, the latest of these flows burst from the north-eastern side of Mauna Loa, at an altitude of about 10,000 feet. From this point it gradually passed down the slope of the mountain, at first toward the north-east; then, making a sharp bend, it flowed for some distance toward the south-east, and then, once more making a sharp bend, took a course directly toward Hilo, a small but pretty village on the eastern coast. The first portion of its course was over a country composed entirely of naked lava above the limits of vegetation. It then entered the belt of forest which skirts the mountain with a